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Network Scheduling of Shipyard Production, Engineering, and Material Procurement

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R ESEARCH
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E NGINEERING
FOR
A UTOMATION
AND
P RODUCTIVITY
IN
S HIPBUILDING

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COST-EFFECTIVE N/C PROCESSING IN A SMALL SHIPYARD

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As Vice-President of Engineering, Mr. Shipley is in charge of the estimating, design, and production engineering functions to support new vessel construction. He has a degree in civil engineering from Montana State University and has held the positions of Engineering Department Head, Planning and Scheduling Manager, and Project Engineer at Marinette Marine Corporation.

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Since the founding of Cali and Associates Inc, Mr. Cali has directed the continuous development of the SPADES system, and expanded the company to provide complete N/C lofting services to the shipbuilding industry, with particular emphasis to the small and medium size shipyards. He has an engineering degree from the Italian Naval Academy.

Mr. Cali has over 30 years experience in all phases of shipbuilding. Prior to founding Cali and Associates, Mr. Cali held the positions of Vice-President for Engineering at Avondale Shipyards, and Director of Engineering at Litton Ship Systems.

PART I - The Shipyard's Viewpoint by W. D. Shipley, Vice President
         Engineering, Marinette Marine Corporation

INTRODUCTION

My role here is to present the rationale behind the shipyard's
recent decision to upgrade its N/C burning facilities and develop
inhouse programming capabilities. Credits for developing and imple-
menting the proposed changes belong to Jim Wilson in the Engineering
Department at Marinette Marine Corporation (MMC) and Filippo Cali of
Cali and Associates (Cali) who spent many hours researching the
alternative ways of generating and transmitting N/C images for ship-
yard use. In addition, Russel Morgan and Douglas Gifford of the
Linde Division of Union Carbide as well as Duane Holloway of Calcomp
must be recognized for their active support to provide the necessary
software and hardware against a tight schedule once a "GO" decision
was made.

BACKGROUND

MMC began N/C burning in 1971 with the acquisition of the first
production unit (Serial No. 1) of Linde Model CM100, with gas torches,
and paper tape controls. The first tapes were purchased from Cali
who has been our N/C source on all programs since, with two exceptions.
The original burning machine was later upgraded to cut with plasma-
arc as well as gas. In 1978 MMC purchased a second burning center,
Linde Model CM150, with plasma and gas torches, and dual mode con-
trols to accept either paper tapes or direct numerical-control com-
mands.

The shipyard has realized greatly improved burning efficiencies
with the combination of N/C controls and plasma torches. However,
the optimization of the burning process created a new set of problems

which neither the shipyard nor Cali was willing to accept as the price of progress. Two basic problems associated with the process of generating and transmitting paper tapes were recognized:

1. SCHEDULE PROBLEMS

    Lead times to produce N/C parts after contract award were often greater than the old manual methods, resulting in schedule slippages for all trades paced by steelwork. In addition, the turn-around time to make tape changes was excessive due mostly to mailing time between Cali & MMC. These changes, usually initiated by the shipyard, disrupted Cali's staff with unscheduled overloads.

2. COST PROBLEMS

    The high costs for making unscheduled tape changes were passed on to the shipyard. In addition, the material cost along for high quality paper tapes was excessive. A recent cost study indicates that the shipyard would save roughly $32,000.00 per year at current production levels by eliminating paper tapes as the N/C control medium.
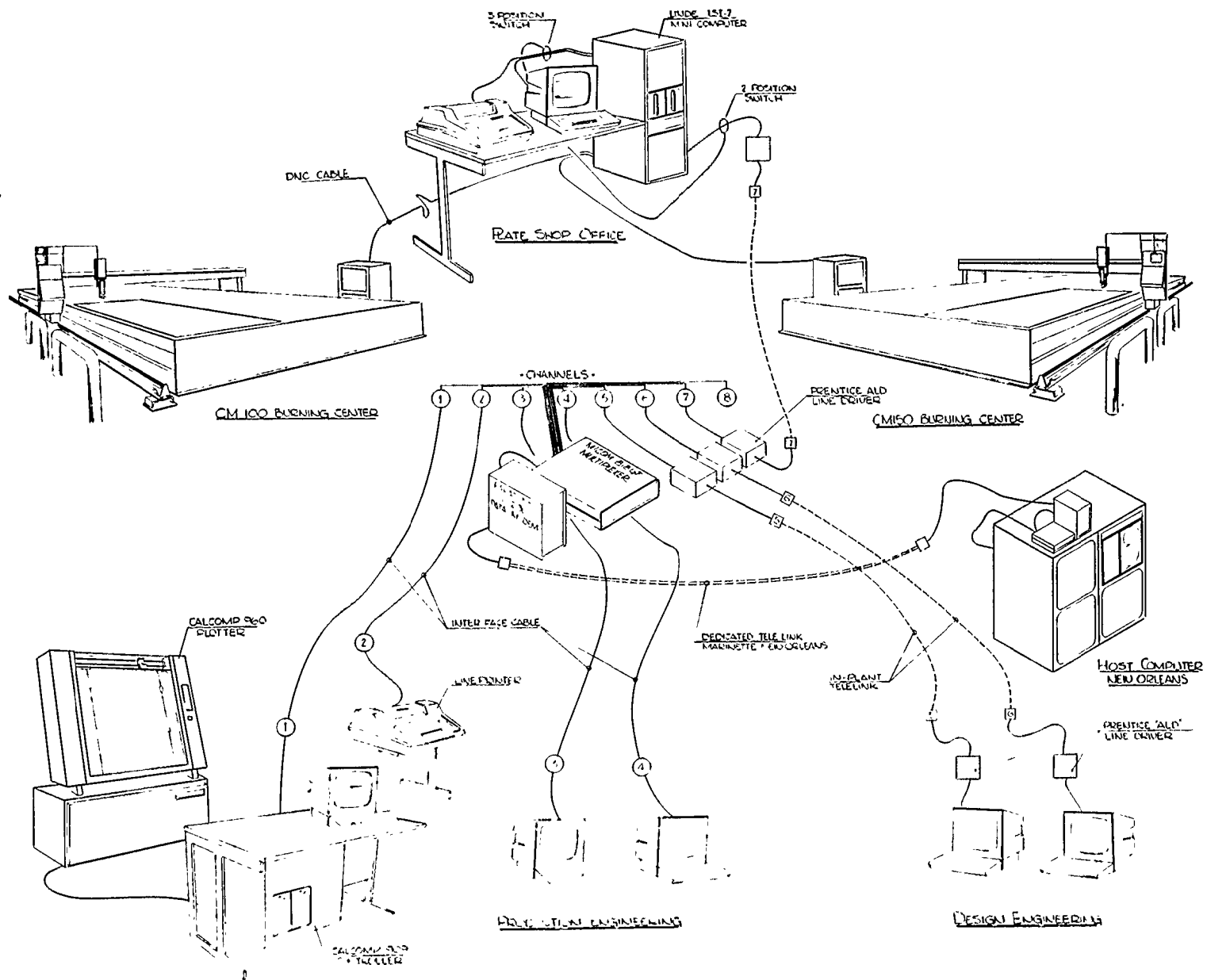
As a result of identifying these problems, it was concluded that the shipyard must develop greater control over the schedules and costs of generating N/C programs. Two goals were proposed and adopted for further study:

1. Convert the burning machine controls from paper tape to DNC mode with direct telecommunication between the burning machine and the host computer to minimize transmission delays between Cali and MMC and to also eliminate paper tape material costs. This change was easily justified as both schedule and cost effective on its own merits.

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2. Develop the capability within the shipyard to ultimately
   perform all N/C programming inhouse. This goal was
   highly constrained by a tight capital equipment budget
   and the difficulty of recruiting and training programmers.
   After considerable "brainstorming" between Cali and MMC
   people, it was concluded that a two-phase approach was
   the optimum solution. The first phase, now being im-
   plemented, would give the shipyard the inhouse capability
   to plot, verify, and nest parts generated and transmitted
   by Cali directly to the shipyard over a dedicated tele-
   communication line. The second phase would add the capa-
   bility to generate parts inhouse after Cali's new Inter-
   active Graphics System was fully developed and proven.

STATUS

   Both proposals (convert to DNC and add partial programming
capability) were approved on May 16 this year. The plotter was
on line with Cali by June 23 and the first part images were trans-
mitted on July 7. The DNC conversion and checkout is on schedule for
completion by september 30, 1979. The shipyard's Management is im-
pressed and pleased with the rapid progress made to implement-the
adopted changes. Details of the system will be covered in the second
part of this paper. Finally, MMC intends to further utilize the new
hardware in the near future with the addition of ship design soft-
ware modules..

3 POSITION SWITCH

L INDE LSI-7 MINI COMPUTER

2 POSITION SWITCH

DNC CABLE

RATE SHOP OFFICE

CM 100 BURNING CENTER

· CHANNELS ·

① ② ③ ④ ⑤ ⑥ ⑦ ⑧

PRENTICE ALD LINE DRIVER

CM150 BURNING CENTER

NICON 8/40 MULTIPLEXER

CALCOMP 960 PLOTTER

INTERFACE CABLE

LINE PRINTER

DEDICATED TELE LINK MARINETTE + NEW ORLEANS

IN-PLANT TELELINK

HOST COMPUTER NEW ORLEANS

PRENTICE 'ALD' LINE DRIVER

CALCOMP 900 PLOTTER

PRODUCTION ENGINEERING

DESIGN ENGINEERING

PART II - Technical Development and Hardware by Filippo Cali, President,
         Cali and Associates, Inc.

Background History of the Development

In order to present the technical side of Marinette Marine's Installation
I think it is proper to review the past events that led to it. It was in
1976 that Cali & Associates developed, jointly with Avondale Shipyards,
the interactive graphics version of the Spades System. A paper on the
subject was presented and a movie shown at the 1976 Reaps Symposium. While
this software has been used successfully by Avondale, the requirement of
a large IBM/370 Main Frame and expensive IBM 2250 CRT's has prevented us
to use it in the course of our N/C service work or to make it available
to any other Spades user.

During the fall of 1978 we started looking for alternatives that would allow
us to continue Interactive Graphics Development and not require a large cap-
ital investment in hardware. The present I/G version of Spades includes:

- Part generation
- Nesting
- Shell Development
- Data Base access and display

It is our intention to further improve the nesting by combing with it an
automatic nesting capability utilizing the Bill of Material, Modules Break-
down and N/C information collected by the "SPAC" (Shipbuilding Production and
Control) module of Spades.

The other area that needs development is the generation of 2 dimensional
drawings for engineering and 3-D (isometric) drawings for production using
graphic CRT's.

In December we selected the host computer we wanted to use and we placed an
order with Prime Computers for the following hardware:

```
P   400 CPU with 1 Megabyte Core
2   300 Megabytes Disk Drives (Removable packs)
1 Mag Tape Drive (800/1600 BPI)
1   600 LPM printer
1   300 CPM Card Reader
2   Bisynchronous Ports
16 Asynchronous Ports
4   80 Character Alphanumeric CRT's
1   132 Character Alphanumeric CRT (VT 100)                    ADDED
1   150 Characters Per Second Teleprinter (T.I. Omni 800)     LATER
```

A tentative selection was also made for the graphic CRT's, but the order
for two 3205 IMLAC's was not placed until July this year since we would
not have had the resources for the conversion and further development of
the graphic software until completion of the equivalent task with the
standard batch version of Spades.

The "Prime" computer was installed on February 1, and by April 1, the conversion and checkout of "Spades" and Data Base Conversion Program was complete.

Even though many changes were necessary, they were made in such a way to maintain total compatibility with the "IBM" version used by all other "Spades" users. This was essential in view of our committment to release yearly the current version of "Spades" with all latest improvements to all users at no cost. It goes without saying it that we make sure the implementation of each release is totally transparent to the user, i.e. "Spades '80'" is totally compatible with Data Bases and input data generated with "Spades '70'".

The program to convert the binary Data Base works both ways from "IBM" to "Prime" and vice versa. That is we generate, using the "Prime" computer, an "IBM" compatible mag-tape to be read directly into a "Spades" "IBM" Data Base.

Since April, when we switched to "Prime", we have concentrated our effort to improve our operation efficiency in that environment, with two broad goals in mind:

- Easy access and use of the system through the various alphanumeric "CRT's"
- On line access and display of the Data Base for all data suitable for alphanumeric display.

During this period the possibility of remote entry and "DNC" (Direct Numerical Control) became more real than in the past. This subject had been discussed many times with Marinette but always postponed because of the capital cost of the hardware and cumbersome software (RJE, HASP, etc.)
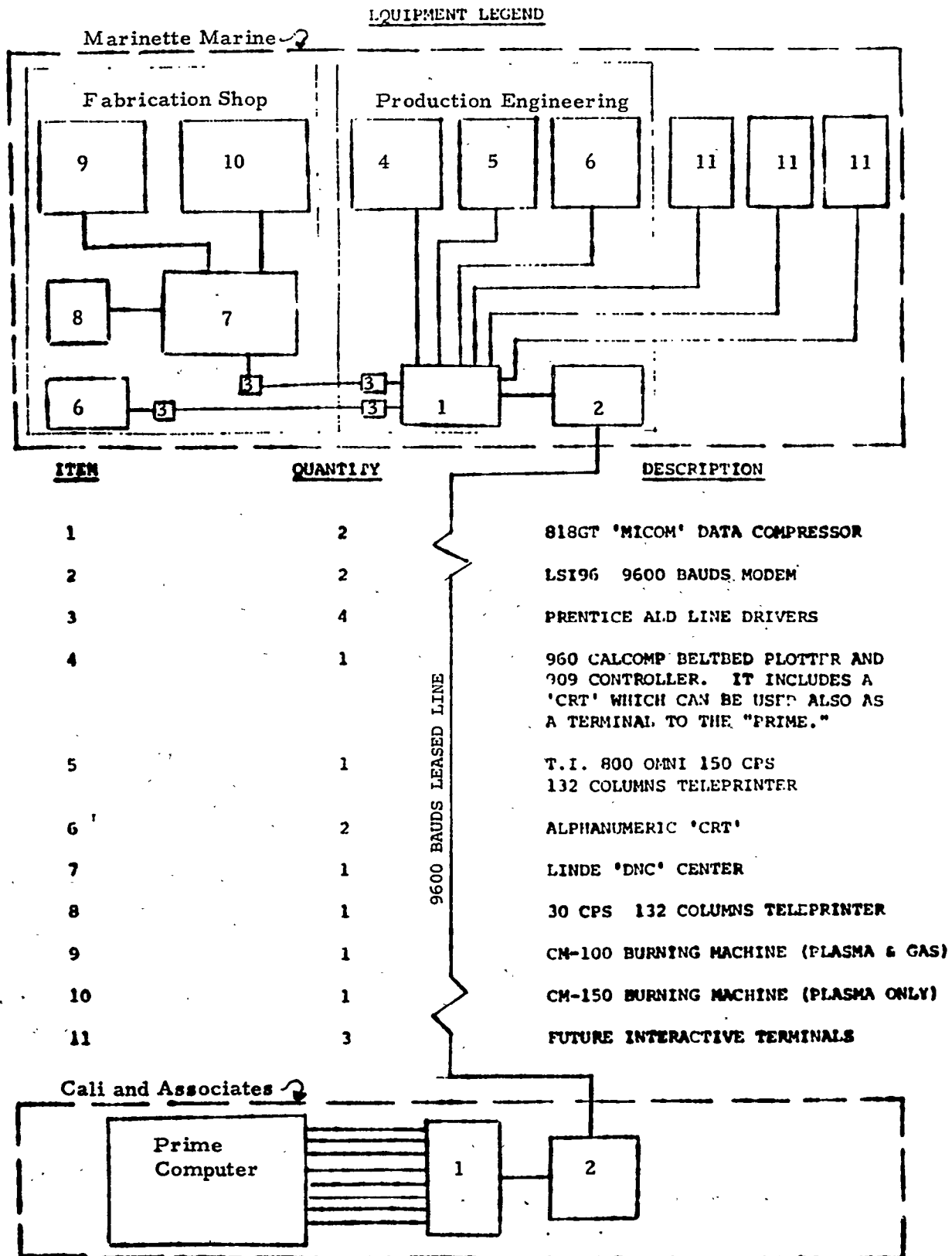
Even with the "Prime", which can host a 2780 terminal, our first approach was again the conventional remote entry with enough hardware at the remote site to handle the numerous communications with the host needed in a shipyard using numerical control in a "DNC" mode. Of course, this alternative preluded totally in line access to the Data Base for both alphanumeric and graphic CRT'S. While looking for communication equipment, we became aware that both cost and availability of hardware had improved to the point where a totally different alternative was possible. Additional software would be needed in the "Prime" to handle the plotter and the burning machine, but the increased flexibility and reduced cost at the shipyard made it worthwhile.

This alternative was discussed with Marinette Marine and at the end of May their management decided to go ahead with it. By the end of June, communication was established to access the "Prime" and drive the Calcomp plotter. Following is a detailed description of the entire installation.

Detailed Description

Fig. (A) shows all components. All devices at the shipyard, in so far as the user is concerned, are at all times in direct and independent communication with the host. Each one is "TTY" compatible and uses an Asynchronous Line.

LQUIPMENT LEGEND

Marinette Marine

Fabrication Shop

| 9 | 10 |

Production Engineering

| 4 | 5 | 6 | 11 | 11 | 11 |

| 8 | 7 |

| 6 |

| 3 | 3 | 1 | 2 |
| 3 | 3 |

ITEM	QUANTITY	DESCRIPTION
1	2	818GT 'MICOM' DATA COMPRESSOR
2	2	LSI96 9600 BAUDS MODEM
3	4	PRENTICE ALD LINE DRIVERS
4	1	960 CALCOMP BELTBED PLOTTER AND 909 CONTROLLER. IT INCLUDES A 'CRT' WHICH CAN BE USED ALSO AS A TERMINAL TO THE "PRIME."
5	1	T.I. 800 OMNI 150 CPS 132 COLUMNS TELEPRINTER
6	2	ALPHANUMERIC 'CRT'
7	1	LINDE 'DNC' CENTER
8	1	30 CPS 132 COLUMNS TELEPRINTER
9	1	CM-100 BURNING MACHINE (PLASMA & GAS)
10	1	CM-150 BURNING MACHINE (PLASMA ONLY)
11	3	FUTURE INTERACTIVE TERMINALS

9600 BAUDS LEASED LINE

Cali and Associates

Prime Computer | 1 | 2 |

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All lines go through the Micom 818GT Data Compressor which packs all data for synchronous transmission through the Paradyne Modem at 9600 Bauds accross a four wires dedicated line from the shipyard to our offices in New Orleans. A matching set of Modem and Micom reverses the packing and distributes all data to the corresponding eight Asynchronous Lines going to the "AMLC."

The advantages of this approach can easily be appreciated when we consider the following sample list of communications with the "Prime" being handled simultaneously:

1. In the burning machine shop the LINDE 'DNC' Center is receiving and storing in floppy disks N/C tape images to be routed to either of the two burning aachines.
2. Still in the shop the 'CRT' is being used to request additional tape images from the "Spades" Data Base or perhaps request a tape image for a single piece, part of a previously cut nested plate, that has been misplaced, damaged, or affected by design changes.
3. In the Production Engineering Department the Calcomp plotter is receiving plotting data to either plot directly or store on floppy's for later plotting.
4. In the Production Engineering Department another 'CRT' is being used to enter input data for execution by "Spades." This function not only replaces the traditional keypunch, but stores the data at the same time in the "Prime."
5. In the Production Engineering Department another 'CRT' is being used for any other miscellaneous task such as:

    . Execution of any "Spades" module
    . Requesting additional plotting files for the Calcomp plotter
    . Accessing the "Spades" Data Base in real time to display and check data or to enter data such as recording the validation of a part or putting under hold a burning machine tape image affected by drawing changes.

6. In the Production Engineering Department the printer is receiving hard copy of title blocks and processing time associated with nested tape images to be released.
7. In production control, a 'CRT' is being used to access "SPAC" to check the status of lofting for a construction module or perhaps to extract the corresponding Bill of Material.
8. In the Design Engineering Department a 'CRT' is in use to enter data and generate hydrostatic curves, damaged stability tank capacity and sounding tables, etc.

The advantages of the above capability over that of a conventional remote batch entry are obvious enough to not require any further elaboration.

The baud rate presently assigned to each of the channels is 1200 with the
exception of the calcomp plotter which uses 4800 baud's. This distribution
is more than adequate when we consider the human speed at each terminal
and the buffering and "No Dead Air" capability of the 818GT Micom.
Marinette's plans for the near future call for the use of the interactive
graphic version of "Spades." I would assume at this time that a four
channels installation similar to one above will be required with each
channel rated at 4800 bauds. In order to better support both our own
and remote graphic terminals we have already scheduled the upgrading in
the first quarter of next year, Of our CPU from the "400" to a "750."

Supporting Software

To make the Marinette installation a practical reality, a considerable
amount of supporting software had to be conceived, developed, and imple-
m e n t e d :

- . Spooling programs to handle communication and transmit data to the
  burning machines and to the plotter with the appropriate protocol
  each required.
- . The generalized "Spades" post-processor had to be modified to
  include the Calcomp. This is one of the instances when the modular
  structure of the "Spades" system has paid off handsomely. By
  changing 'the post-processor all "Spades" modules with graphic
  outup acquired the Calcomp option, whether to plot a set of curves
  of form or a nested tape image.
- . All procedures for execution of Spades both batch type or inter-
  active had to be modified to recognize each user and check the right
  of the user to access any of the ships in the Data Base. That is,
  Marinette can only access Marinette jobs.
  The "Spades" output also had to be screened to insure compatibility
  with the receiving device, i. e.

  - . The burning machine should only receive data in the format
    required by the LCNC-6 and UCNC controllers.
  - . The Calcomp Should receive only Calcomp plotting data.
  - . Form control for the printer has to be the appropriate for
    that type vs. the conventional 600 LPM printer at our office.

The development of this software required in some cases a considerable amount
of adaption on our part. For instance the "909" controller of the plotter
does not allow at the present storing more than one plot file in any one disk.
To accept this limitation, it would have meant a continuous changing and
storing of floppies. Instead, the spooler was designed to keep the plot file
open and accumulate all the separate drawings in one single plot file, that
would be closed only at user's request. This, of course, imposed the neces-
sity of creating Calcomp search addresses (pointers within the plot file),
associating them with the user's drawings' names and recording them for future
reference to the user when plotting in a random sequence from the plot file.

As a further aid to the operator of the plotter, changes were made to "Spades" System that cause a stop at the beginning of each logical drawing and display a message on the 'CRT' stating X & Y dimensions in inches required by the drawing. If the "Spades" system finds the area required by the drawing to be larger than the maximum for the plotter the scale is automatically reduced and a message displayed to the operator.

This last feature is now part of the system for all installations whether or not operating in a "DNC" mode. The only difference being that the message is written on the drafting machine through the paper tape itself.

Closing Remarks

The entire development described above would have not materialized without Marinette Marine's tradition to commit to new technology without waiting to be proven first somwhere else.

I would like also to take this opportunity to point out that, as in the past for all "Spades" developments, this also was accomplished with financing from the private industry without any government grant and associated red tape. The April to July time span from conception to implementation of this project offers in itself the best proof of the cost effectiveness of the free enterprise approach vs. government financing.

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